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ABSTRACT

This survey of 316 Precalculus, Calculus AB, and Calculus BC students from markedly different socioeconomic levels in four district high schools in San Antonio, Texas, looked at factors that have traditionally caused women to avoid mathematics, and attempted to discover which of them continue to influence women's decisions to reject the discipline. The questionnaire contained 25 questions based on assumptions drawn from literature on the subject. Reported and discussed are all differences in gender opinion above 9 percentage points, even though a difference of 11.4 percentage points would begin to indicate a statistically significant result. Findings where such differences occur showed that: (1) mathematics enrollment favored men, especially in BC Calculus; (2) female respondents more frequently perceived no bias in teacher expectations; (3) female students less frequently thought that the gender of their mathematics teacher had any effect on their learning; (4) males rated mathematics as more useful and having practical value in earning a living than females; (5) males more frequently strongly agreed that they were confident about doing well in the next math courses; and (6) male students more frequently agreed that their gender had greater aptitude for math. These findings regarding confidence are dramatic, since women's grades in all three classes averaged the same or higher than male counterparts. It is concluded that adult influences have come far in rejecting old biases, but that students' self-concepts appear to be deeply entrenched. (MDH)

Gender Equity in High School Math: A Study of Female Participation and Achievement

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One of the educational cliches of the last few decades has been that a technologically advanced society demands a mathematically literate workforce, and that this demand will grow at an unprecedented rate into the twenty-first century. It is also much noted that student interest and aptitude in math has fallen off precipitously in recent years. Not only have SAT scores shown a general decline, but recent statistics show an alarming decrease in the number of students pursuing graduate work in math-related disciplines. 1988 reportedly marked a twenty-year low in the number of graduate math degrees earned by Americans (McGlone, 1988), as law and business schools continue to siphon off many from the ranks of those who might have traditionally pursued study in those areas.

The national retreat from mathematics-related disciplines has been aggravated too, it seems, by the persistent failure of women to enter these disciplines. In the mid-sixties, when women first began to flesh out the ranks of doctoral programs across the country, it was popularly assumed that such traditionally male graduate departments as those in math and science would come to

accept equal numbers of women as men. This has not happened. Though occasional studies have indicated some improvement in female participation in advanced math and science courses (Rallis,1986), the vast majority of research in this area suggests that change has been surprisingly slow (Meece, 1982; Sells, 1980; Sherman and Fennema, 1977). Clearly, women are continuing to avoid those academic routes which would lead them into technologically-oriented fields.

This study looks at a number of factors that have traditionally caused women to avoid mathematics, and attempts to discover which of them continue to influence women's decisions to reject the discipline. Our research reexamined those beliefs and phobias which the literature in the area has identified as most common in students who fail to pursue mathematics. Many of the classic investigations of gender inequity in math were performed in the late seventies. We were curious to see what progress, if any, had been made in the intervening years with regard to these issues.

The study focuses on female participation and achievement at the high school level because we believe that it is in high school where key choices are made that ultimately serve to disqualify many women from considering math-related disciplines at a later point. Studies show that negative biases formed in high school are rarely undone in college (Sells, 1978). And students who avoid math as undergraduates are excluded from a great range of graduate

school and career options. One University of California study, for example, shows that 92% of entering females lacked the four years of high school math which would render them eligible for twenty-two out of forty-four majors at Berkeley (Sells, 1978).

The literature which exists in the area of women and math has tended to focus on two domains: the biological and the social. Sex differences in mathematical ability have been attributed to genetic differences, differences in brain organization, and hormonal factors (Meece, 1982; McGlone, 1980). Other popular biological explanations include the hypothesis that innate spatial visualization abilities--abilities more pronounced in men--mediate mathematical achievement. Several studies have demonstrated a strong correlation between mathematical achievement test scores and spatial skills (Meece, 1982; Fennema & Sherman, 1977, 1978; Sherman, 1980). Other studies, however, show an equally strong correlation between math performance and verbal skills--traditionally an area of strength for women (Fennema & Sherman, 1977, 1978; Sherman, 1980). Taken together, the literature supporting the theory of biological determinants is, at best, inconclusive.

The research on socialization factors is more compelling. Socializers (parents, teachers, and counselors in particular) have been shown to contribute to math-attitudes in a number of ways: 1. as role models 2. by setting different expectations for males and females 3. and

by providing and encouraging different activities for male and female children. A range of persuasive studies exist in this area: Research by Ernest (1976), for example, supports theories concerning role model influence. Fathers, he reports, help their children more often than mothers with math homework after the sixth grade. Other studies (Meece, 1982) have reported a disproportionate number of male math teachers in advanced math courses. Past research on teacher attitudes have also tended to show negative bias against females. Surveys of elementary and high school teachers have shown that a substantial percentage expected boys to excel in math. No teachers studied expected girls to outperform boy students (Ernest, 1976). Abel (1983) has reported that parents are more likely to offer rewards to male rather than female children for excelling in math. Studies have shown, too, that counselors admit to discouraging girls from taking high level math courses, based on their own stereotyped views of gender abilities (Meece, 1982). Indeed, counselors' may develop these biases through their own academic training. A recent review of 100 general psychology textbooks revealed that 91% presented as fact that men have greater mathematical ability than women (Collier, 1989). In short, since the late 1970's persuasive evidence has existed to support the notion that math interest and ability is strongly influenced by social norms and implicit messages.

Design of the Study

Data for this study were collected from 316 Precalculus, Calculus AB, and Calculus BC students in four district schools in San Antonio, Texas. The courses cited above are the three most advanced math courses taught in public secondary schools in Texas. These classes were chosen as the object of study because they were apt to attract students of strong ability who would be most likely to pursue math in college and beyond. The socioeconomic levels of students surveyed differed markedly, with average family incomes ranging from less than $15,000 per year to over $50,000. Ethnic and racial breakdowns in the four schools also varied, with Hispanic and Mexican-American populations as high as 60% in one school, and as low as 20% in another. Within the advanced math classes surveyed, minority enrollment averaged 10%. Of the nearly 12,000 high school students in the district, only 2.7% are enrolled in these advanced courses, and thus represented in the survey.

The questionnaire used in the study was of our own design, with questions based on assumptions drawn from literature on the subject. The survey was divided into six parts, with 25 questions in all. In designing the survey questions, we sought to divide those variables affecting math participation and achievement into two general categories, external variables and internal variables. External variables were defined as those factors which were unrelated to innate preference, attitude, and self-concept. Examples of such external motivators were 1. the perceived

practicality of math in relation to future goals or career 2. parental and/or teacher recommendations and prohibitions 3. the presence or absence of role models 4. and peer pressure or support. Internal variables were defined as 1. perceived aptitude and 2. perceived locus of control e.g. to what extent did the student attribute his success in math to effort vs. luck. A three- four- or five-point Likert scale was used for all responses.

Reported and discussed here are all differences in gender opinion above nine percentage points, though following a normal distribution, it is estimated that a difference of 11.4 percentage points would begin to indicate a statistically significant result. Though this was not a formal statistical study, we believe that the findings of the survey are indeed noteworthy, and clearly suggest avenues for further research.

Findings

Figure 1 indicates enrollment numbers divided by gender for the three courses surveyed. Proportionate male and female enrollment are 57% and 43% respectively, with a difference of 14 percentage points in favor of men. Inequity in female enrollment was most pronounced in the most advanced math class, BC Calculus, where males represented approximately 76% of the overall enrollment. Taken together, however, female participation in these courses seems

significantly higher than has been reported in previous studies.

Other findings also show shifts from established norms. The area of teacher influence provides a dramatic example. Fennema and Sherman (1978) have reported that boys perceived their teachers as being more successful learners of math than girls, and this perception became even more pronounced in high school. Girls, they found, "perceived their teachers as being significantly less positive towards them as learners of math." Our own survey indicates a change in perceived teacher attitudes on the part of both sexes. Figure 2 shows that only 3.9% more males than females perceived teacher bias in favor of their respective genders. Furthermore, 95.6% of female respondents perceived no bias at all in teacher expectations, a figure which is 9.5 percentage points greater than the one reported by male students. In response to the question, "Do you think the gender of your math teacher has an effect on your learning?" results again were contrary to expectation (see Figure 3). Only 9.6% of all female students agreed with the statement, a significantly lower percentage than males, suggesting, it seems, that issues of teacher bias and the absence of female role models in mathematics may have less impact on female attitudes than has been previously assumed.

Similar lack of gender bias was perceived from parents and counselors. Whereas Meece (1982) and others have reported that girls are less likely than boys to be

encouraged by parents to enroll in advanced level math classes, our survey found sexes equally supported by both mothers and fathers, with a difference between the two of three percentage points or less (see Figures 4 and 5). Counselor recommendations either for or against enrollment in advanced classes were reported by both male and female students to have negligible effect on their decisions to enroll in those classes.

In the area of perceived math-usefulness in future life and career our survey findings tended to support those of earlier research. Meece (1982) has summarized the results of numerous studies which have all found that boys, as early as 7th and 8th grade, tend to rate math as more useful than do girls. Our survey (Figures 6,7,and 8) showed a difference of 9.2 percentage points in favor of males among those students who agree that math "is useful in daily life"; 13.2 percentage points in favor of males among those students who agree "that math has practical value in earning a living"; and 17 percentage points in favor of males among those who agree strongly that math "is necessary for their intended major or career". It is interesting to note that a significantly higher percentage of female students than male considered "college preparation" their top-rated reason for taking math; suggesting perhaps that female students surveyed were more concerned with college entrance into competitive schools, and with completing math requirements

there, than they were with actually pursuing math as a major or a career.

In the area of self-confidence and self-esteem, our survey results again support traditional assumptions about women in this area. Meece (1982), Fennema and Sherman (1978), and others have reported that males were significantly more confident about their ability to learn math than were females. Here (see Figure 9),a difference of 10.6 percentage points favors males who strongly agreed that they were confident about doing well in their next math courses. 15.5 and 12.6 percentage points separate female from male students when rating themselves among the best of female and male classmates, respectively (Figures 10 and 11). Finally, 36.9% of the male students agreed that men have greater aptitude for math than women. Only 6% of women attributed greater ability to their own gender (Figure 12).Differences in the level of confidence between the two sexes appears even more dramatic in light of statistics regarding actual performance in class. Women's grades in all three classes averaged the same or higher than those of their male counterparts.

Of particular interest regarding male confidence is our survey's finding that 19.4% of male students report that enrollment in high level math has a positive effect on their popularity. In addition, the survey suggests that males are more likely than females to be encouraged by peers to pursue advanced mathematics. While 98% of each gender reports no

experience of negative effect on popularity, a difference of 12.8 percentage points indicates that boys are more likely than girls to experience a popularity boost from their success in the discipline (Figure 13).

Conclusions

The results of this informal study suggest that even at the high school level--and even among those young women most talented in the area of mathematics--negative assumptions regarding gender continue to exist in mathematics. Significant percentages of young women in our study appear to assume inferiority to men in all aspects of mathematical ability--even when clear evidence exists to the contrary. Disinterest in math-related careers on the part of these women seems likely to be related to that insecurity. Our study suggests that some young women may already feel, as early as junior or senior year, that they are less qualified than men to compete for key jobs in technological areas.

Particularly interesting is the disjunction between the perceived opinions of "socializers," and students' self-esteem. This study shows that adult influences have come far in rejecting those old biases formerly attributed to them. Students reported sensing virtually no stereotyping or unequal treatment from parents, teachers, or counselors. Indeed, in some cases, women sensed greater support for their mathematical interest than did men. In this sense, progress has clearly been made. Unfortunately, the

enlightened attitudes of these socializers seem to have had less impact on their charges than might be expected. Students' self-concepts appear deeply entrenched, with stereotypes about female inferiority remaining apparently little fazed by external support systems.

As reported above, young women gained nothing in the way of peer status by choosing to take advanced math courses. Young men, by contrast, saw their choice as representing a clear gain in popularity. In another section of the questionnaire, 58.4% of the young women surveyed still claimed to believe that "men dislike women who are as smart or smarter than they are." These statistics say much about the distance yet to be travelled towards real equality. An enlightened educational establishment, it seems--including teacher role models--can do little to counter the more powerful sexist messages sent by the society as a whole. Unless the popular culture begins to reflect in earnest the values of that enlightened minority, even the most noble expectations of educators will be defeated by the students themselves. It is the <u>culture</u>, not simply the schools, which must sell the notion of women and mathematics.

On the new Star Trek, which depicts a world far beyond the era of Captain Kirk and Mr. Spock, the chief operations officers are still men. To be sure, women do have a place in this futuristic society: They are depicted as nurturing doctors, telepathic aliens, and communications specialists.

But the computer wizards, the chief scientists, the real leaders are all male. Before high school girls begin to choose, in substantial numbers, those routes which will lead them into math-related fields, starships like the Enterprise, it seems, will need to piloted on primetime by women.

Note

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Figure 1.
Enrollment numbers for Precalculus, Calculus AB, and Calculus BC, by gender:

	MALE	FEMALE	TOTAL
PRECALCULUS	95	67	162
CALCULUS AB	56	60	116
CALCULUS BC	29	9	38
TOTAL	180	136	316

Figure 2.
"Do you think your math teacher has different expectations for girls and boys in your class?" (A-no difference; B-expects girls to do better; C-expects boys to do better).

	A	B	C
MALE	86.1	7.8	6.1
FEMALE	95.6	2.2	2.2
DIFFERENCE	9.5	5.6	3.9

Figure 3.
"Do you think the gender of your math teacher has an effect on your learning?" (A-yes; B-no; C-no opinion).

	A	B	C
MALE	25.2	73.7	3.1
FEMALE	9.6	90.4	0

Figure 4.
"Describe the attitude of your mother toward your pursuit of mathematics." (1-very supportive; 2-moderately supportive; 3-neither favorable nor unfavorable; 4-unfavorable).

	1	2	3	4	1&2
MALE	61.1	20.0	13.9	0	86.1
FEMALE	69.9	13.2	15.4	1.5	83.1
DIFFERENCE					3.0

Figure 5.
"Describe the attitude of your father toward your pursuit of mathematics."

	1	2	3	4	1&2
MALE	70.8	13.5	15.2	0.6	84.2
FEMALE	69.4	15.7	14.9	0	85.1
DIFFERENCE					0.9

Figure 6.
"Knowledge of math will be of some use in everyday life." (1-strongly disagree; 2-moderately disagree; 3-moderately agree; 4-moderately agree).

	1	2	3	4	1&2	3&4
MALE	16.1	32.8	42.2	8.9	48.9	51.1
FEMALE	21.3	36.8	36.0	5.9	58.1	41.9
DIFFERENCE					9.2	9.2

Figure 7.
"Knowledge of math will have practical value for me in earning a living."

	1	2	3	4	1&2	3&4
MALE	6.7	12.8	45.0	35.6	19.5	80.6
FEMALE	5.2	27.4	47.4	20.0	32.6	67.4
DIFFERENCE					13.1	13.2

Figure 8.
"Math courses are needed for my intended major field or future work."

	1	2	3	4	1&2	3&4
MALE	6.7	11.2	22.9	59.2	17.9	82.1
FEMALE	11.9	16.3	29.6	42.2	28.2	71.8
DIFFERENCE				17.0	10.3	10.3

Figure 9.

"I feel confident about doing well in the next math course I take." (1-strongly agree; 2-moderately agree; 3-neither agree nor disagree; 4-moderately disagree; 5-strongly disagree).

	1	2	3	4	5	1&2	4&5
MALE	43.0	36.3	13.4	6.1	1.1	79.3	7.2
FEMALE	32.4	39.0	15.4	11.0	2.2	71.4	13.2
DIFFERENCE	10.6					7.9	6.0

Figure 10.

"How would you rate your mathematical ability in comparison with the girls in your class?" (1-among the best; 2-above average; 3-average; 4-below average; 5-among the poorest).

	1	2	3	4	5
MALE	39.9	24.7	30.9	2.8	1.7
FEMALE	24.4	23.7	42.2	8.9	0.7
DIFFERENCE	15.5				

Figure 11.

"How would you rate your mathematical ability in comparison with the boys in your class?"

	1	2	3	4	5
MALE	36.3	22.9	34.6	5.6	0.6
FEMALE	23.7	19.3	39.3	17.0	0.7
DIFFERENCE	12.6				

Figure 12.

"Which gender has the greater aptitude for math?" (A-women; B-men; C-neither).

	A	B	C
MALE	5.6	36.9	57.5
FEMALE	5.9	20.0	74.1
DIFFERENCE	0.3	16.9	16.6

Figure 13.
"In what way dces being in an advanced math class effect your popularity in school?" (A-positively; B-no difference; C-negatively).

	A	B	C
MALE	19.4	78.9	1.7
FEMALE	6.6	91.2	2.2
DIFFERENCE	12.8	12.3	0.5